Claims

[c1] A method for generating a polarization-multiplexed optical clock signal for an optical communication system, the method comprising:
splitting a polarized input optical clock signal having a clock rate into a first and a second polarized optical signal, wherein the first polarized optical signal comprises a first polarization state and the second polarized optical signal comprises a second polarization state;
delaying the first polarized optical signal relative to the second polarized optical signal; and
combining the first and the second polarized optical signals to generate the polarization-multiplexed optical clock signal for the optical communication system.

[c2] The method of claim 1 wherein the first polarization state is orthogonal to the second polarization state.

[c3] The method of claim 1 wherein the first and the second polarization states are linearly polarized.

[c4] The method of claim 3 wherein the first polarization state is orthogonal to the second polarization state.

[c5] The method of claim 1 wherein the first and second polarization states are circularly polarized.

[c6] The method of claim 5 wherein the first polarization state is orthogonal to the second polarization state.

[c7] The method of claim 1 wherein at least one of the first and the second polarized optical signals is controllably attenuated.

[c8] The method of claim 1 wherein the delaying of the first polarized optical signal relative to the second polarized optical signal comprises propagating the first and the second polarized optical signals along a first and a second optical path, respectively, wherein an optical path length of the first optical path is not equal to an optical path length of the second optical path.

[c9] The method of claim 1 wherein the delaying of the first polarized optical signal relative to the second polarized optical signal comprises propagating the first and the second polarized optical signals through a first and a second polarization plane, respectively, of a birefringent medium, the first and the second polarization planes being characterized by a first and a second propagation velocity of light, respectively.

[c10] The method of claim 1 wherein the combining of the first and the second polarized optical signals to generate the polarization multiplexed optical clock signal comprises rotating at least one of the first and the second polarization states.

[c11] The method of claim 1 wherein the polarization-multiplexed optical clock signal has a clock rate that is substantially twice the clock rate of the input optical clock signal.

[c12] The method of claim 1 wherein the polarization-multiplexed optical clock signal has a clock rate that is more than twice the clock rate of the input optical clock signal.

[c13] A polarization-multiplexed optical clock for an optical communication system, the polarization-multiplexed optical clock comprising:
an optical clock that generates an optical clock signal having a clock rate at an optical clock output; and
a polarization multiplexer having an input that is optically coupled to the optical clock output, the polarization multiplexer generating a polarization-multiplexed optical clock signal having a clock rate at a polarization multiplexer output.

[c14] The polarization-multiplexed optical clock of claim 13 wherein the polarization multiplexer comprises a birefringent medium having a first and a second polarization plane characterized by a first and a second propagation velocity of light, respectively.

[c15] The polarization-multiplexed optical clock of claim 14 wherein the second polarization plane is substantially orthogonal to the first polarization plane.

[c16] The polarization-multiplexed optical clock of claim 14 wherein the birefringent medium comprises a polarization-maintaining optical fiber having a first and a second polarization plane.

[c17] The polarization-multiplexed optical clock of claim 16 wherein the first and the second polarization planes are oriented at substantially forty-five degrees relative to a plane of polarization of the optical clock signal.

[c18] The polarization-multiplexed optical clock of claim 16 wherein an angle of the first and the second polarization planes is adjustable relative to a plane of polarization of the optical clock signal.

[c19] The polarization-multiplexed optical clock of claim 14 wherein the birefringent medium comprises a birefringent optical crystal.

[c20] The polarization-multiplexed optical clock of claim 14 further comprising an optical coupler that optically couples the birefringent medium to the optical communication system.

[c21] The polarization-multiplexed optical clock of claim 14 wherein the first and the second polarization planes of the birefringent medium are oriented at substantially forty-five degrees relative to a plane of polarization of the optical clock signal.

[c22] The polarization-multiplexed optical clock of claim 14 wherein an angle of the first and the second polarization planes of the birefringent medium is adjustable relative to a plane of polarization of the optical clock signal.

[c23] The polarization-multiplexed optical clock of claim 14 further comprising a second birefringent medium having an input that is optically coupled to an output of the birefringent medium, the second birefringent medium generating a second polarization-multiplexed optical clock signal having a clock rate that is twice the clock rate of the polarization-multiplexed optical clock signal.

[c24] The polarization-multiplexed optical clock of claim 23 wherein a polarization plane of the second birefringent medium is oriented at substantially forty-five degrees to the first and the second polarization planes of the birefringent

medium.

[c25] The polarization-multiplexed optical clock of claim 13 wherein the polarization multiplexer comprises:
an optical beamsplitter that splits the optical clock signal into a first and a second optical signal;
a first and a second polarization-maintaining optical fiber that receives the first and the second optical signals, respectively, an optical path length of the first polarization-maintaining optical fiber being different from an optical path length of the second polarization-maintaining optical fiber by an optical path difference, wherein the first optical signal is delayed relative to the second optical signal by a time that is proportional to the optical path difference; and
an optical combiner that combines the first and the second optical signals, thereby forming a polarization multiplexed optical clock.

[c26] The polarization-multiplexed optical clock of claim 13 wherein the polarization-multiplexed optical clock signal has a clock rate that is substantially twice the clock rate of the optical clock signal.

[c27] The polarization-multiplexed optical clock of claim 13 wherein the polarization-multiplexed optical clock signal has a clock rate that is more than twice the clock rate of the optical clock signal.

[c28] The polarization-multiplexed optical clock of claim 13 wherein the polarization multiplexer further comprises an adjustable optical attenuator.

[c29] The polarization-multiplexed optical clock of claim 13 wherein the optical clock signal comprises a linearly polarized optical clock signal.

[c30] The polarization-multiplexed optical clock of claim 13 wherein the polarization multiplexer comprises:
a polarization-maintaining optical fiber having an input that is optically coupled to the optical clock output, the polarization-maintaining optical fiber having a first and a second polarization plane; and
a phase modulator in optical communication with the polarization-maintaining fiber, the phase modulator generating a polarization-multiplexed optical clock

signal having a clock rate.

[c31] The polarization-multiplexed optical clock of claim 30 wherein the first and the second polarization planes are oriented at substantially forty-five degrees relative to a plane of polarization of the optical clock signal.

[c32] The polarization-multiplexed optical clock of claim 30 wherein an angle of the first and the second polarization planes is adjustable relative to a plane of polarization of the optical clock signal.

[c33] The polarization-multiplexed optical clock of claim 30 wherein the polarization-multiplexed optical clock signal has a clock rate that is substantially twice the clock rate of the optical clock signal.

[c34] The polarization-multiplexed optical clock of claim 30 wherein the polarization-multiplexed optical clock signal has a clock rate that is more than twice the clock rate of the optical clock signal.

[c35] The polarization-multiplexed optical clock of claim 30 wherein the phase modulator comprises an active lithium niobate phase modulator.

[c36] A polarization-multiplexed optical clock for an optical communication system, the polarization-multiplexed optical clock comprising:
an optical clock that generates a linearly polarized optical signal having a clock rate at an optical clock output; and
a birefringent medium having an input that is optically coupled to the optical clock output, the birefringent medium having a first and a second polarization plane characterized by a first and a second propagation velocity of light, respectively, wherein the linearly polarized optical signal is split into at least a first optical signal and a second optical signal that propagate in the first and the second polarization planes, respectively, thereby generating a polarization-multiplexed optical clock signal at an output.

[c37] The polarization-multiplexed optical clock of claim 36 wherein the second polarization plane is substantially orthogonal to the first polarization plane.

[c38] The polarization-multiplexed optical clock of claim 36 wherein the birefringent

medium comprises a polarization-maintaining optical fiber having a first and a second polarization plane.

[c39] The polarization-multiplexed optical clock of claim 38 wherein the first and the second polarization planes are oriented at substantially forty-five degrees relative to a plane of polarization of the optical clock signal.

[c40] The polarization-multiplexed optical clock of claim 38 wherein an angle of the first and the second polarization planes is adjustable relative to a plane of polarization of the optical clock signal.

[c41] The polarization-multiplexed optical clock of claim 36 wherein the birefringent medium comprises a birefringent optical crystal.

[c42] The polarization-multiplexed optical clock of claim 36 further comprising an optical coupler that optically couples the birefringent medium to the optical communication system.

[c43] The polarization-multiplexed optical clock of claim 36 wherein the first and the second polarization planes of the birefringent medium are oriented at substantially forty-five degrees relative to a plane of polarization of the optical clock signal.

[c44] The polarization-multiplexed optical clock of claim 36 wherein an angle of the first and the second polarization planes of the birefringent medium is adjustable relative to a plane of polarization of the optical clock signal.

[c45] The polarization-multiplexed optical clock of claim 36 wherein the birefringent medium further comprises an adjustable optical attenuator.

[c46] The polarization-multiplexed optical clock of claim 36 further comprising a second birefringent medium having an input that is optically coupled to an output of the birefringent medium, the second birefringent medium generating a second polarization-multiplexed optical clock signal having a clock rate that is twice the clock rate of the polarization-multiplexed optical clock signal.

[c47] The polarization-multiplexed optical clock of claim 46 wherein a polarization

plane of the second birefringent medium is oriented at substantially forty-five degrees to the first and the second polarization planes of the birefringent medium.

[c48] A polarization-multiplexed optical clock comprising:
a means for generating an optical clock signal comprising a train of optical pulses having a polarization state;
a means for optically splitting the optical clock signal into a first optical signal and a second optical signal, each of the first and the second optical signals having a first and a second polarization state, respectively;
a means for delaying the first optical signal relative to the second optical signal;
a means for rotating the first polarization state of the first optical signal relative to the second polarization state of the second optical signal, wherein the rotating of the first polarization state relative to the second polarization state orients the first polarization state substantially orthogonal to the second polarization state; and
a means for optically combining the first optical signal and the second optical signal to generate the polarization-multiplexed optical clock signal.

[c49] The polarization-multiplexed optical clock of claim 48 further comprising a means for attenuating at least one of the first and the second optical signals.